$$F_x = F \cos \theta \qquad\qquad F = \sqrt{F_x^2 + F_y^2} \qquad \ast\ ①$$
$$F_y = F \sin \theta \qquad\qquad \theta = \tan^{-1} \frac{F_y}{F_x}$$

$$\sin \theta = \frac{a}{b} \qquad\qquad\qquad\qquad\qquad\qquad b^2 = a^2 + c^2 \qquad \ast\ ②$$

$$\cos \theta = \frac{c}{b}$$

2/5

$\tan^{-1}$

$$F_x = -F\left(\frac{3}{5}\right)$$
$$= -1800 \left(\frac{3}{5}\right)$$
$$= -1080 \ N$$

1800 N

$$b^2 \pm 3^2 + 4^2$$
$$= \sqrt{25} = 5$$

$$F_y = -F\left(\frac{4}{5}\right)$$
$$= -1800 \left(\frac{4}{5}\right)$$
$$= -1440 \ N$$

$$F = F_x \hat{i} + F_y \hat{j}$$
$$= -1080 \hat{i} - 1440 \hat{j} \ N$$

2/7

2 kN
3 kN

$$R_x = 3\left(\frac{3}{5}\right) + 2 \cos 30$$
$$= 1.8 + 1.732$$
$$= 3.53 \ kN$$

30°
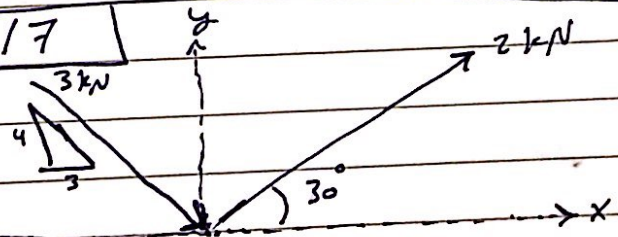
$$R_y = -3\left(\frac{4}{5}\right) + 2 \sin 30°$$
$$= -2.4 + 1$$
$$= -1.4 \ kN$$

$$\theta = \tan^{-1}\left(\frac{-1.4}{3.53}\right) = 28.6°$$

$$R = \sqrt{R_x^2 + R_y^2} = 3.8 \ kN$$

$\theta = 30°$, $\beta = 10°$

$F_x = - F \sin \beta$

$= -100 \sin 10° = \underline{-17.36 \ N}$

$F_y = F \cos \beta$

$= 100 \cos 10° = \underline{98.5 \ N}$

Now, $F_n = F_x \cos \theta + F_y \sin \theta$

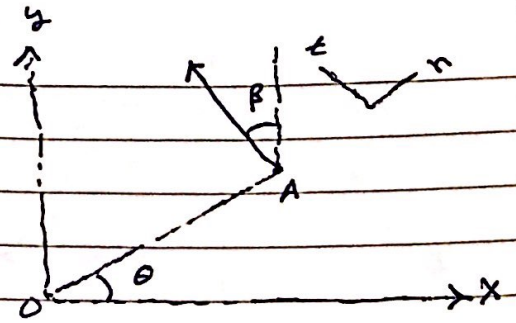$= -17.36 \cos 30° + 98.5 \sin 30°$

$= \underline{34.2 \ N}$ normal components

$F_t = - F_x \sin \theta + F_y \cos \theta$

$= -(-17.36 \sin 30°) + 98.5 \cos 30°$

$= \underline{94 N}$ tangential comp.

(b) $\theta = 15°$, $\beta = 25°$

$F_x = - F \sin \beta$

$= -100 \sin 25 = \underline{-42.26 \ N}$

$F_y = F \cos \beta$

$= 100 \cos 25 = \underline{90.63 N}$

Now, $F_n = F_x \cos \theta + F_y \sin \theta$

$= -42.26 \cos 15 + 90.63 \sin 15$
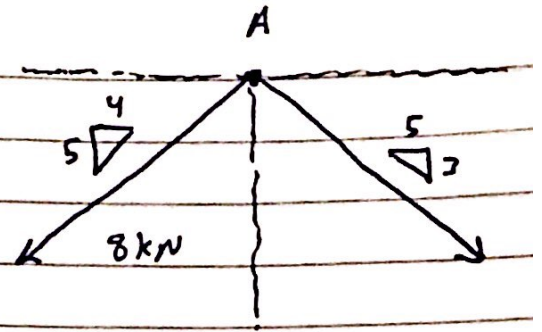
$= \underline{-17.36 N}$

$F_t = -(-42.26 \sin 15) + 90.63 \cos 15$

$= \underline{98.5 N}$

$\Sigma F_x = 0$

$-T_{AB}\left(\dfrac{4}{\sqrt{4^2+5^2}}\right) + T\left(\dfrac{5}{\sqrt{3^2+5^2}}\right) = 0$

$-8\left(\dfrac{4}{\sqrt{4^2+5^2}}\right) + T\left(\dfrac{5}{\sqrt{3^2+5^2}}\right) = 0$

$-5 + \cdot857\,T = 0 \implies \underline{T = 5.83\,N}$ for AC

$\Sigma F_x = R$

$8\left(\dfrac{5}{\sqrt{4^2+5^2}}\right) + 5.83\left(\dfrac{3}{\sqrt{3^2+5^2}}\right) = R$

$6.25 + 3 = R \implies \underline{R = 9.25\,kN}$

$R_x = T + T\cos 60°$

$\quad = 400 + 400\cos 60° = \underline{600\,N}$
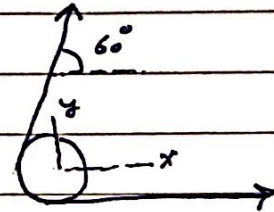
$R_y = T\sin 60°$

$\quad = 400\sin 60° = \underline{346\,N}$

$R = R_x\,\hat{i} + R_y\,\hat{j} \implies R = 600\hat{i} + 346\hat{j}\ N$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{600^2 + 346^2} = \underline{693\,N}$

$\dfrac{L}{D} = 10$

$\dfrac{200}{D} = 10 \qquad D = 20\,N$
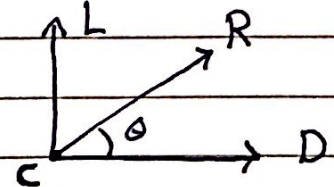
$R = \sqrt{L^2 + D^2} = \sqrt{20^2 + 200^2} = \sqrt{400 + 40000} = \cancel{200.1\,N}\ \boxed{201\,N}$

$\theta = \tan^{-1}\dfrac{L}{D} \implies \theta = \tan^{-1}\left(\dfrac{200}{20}\right) = 84.3° \ \checkmark$

$$R_x = 200 \cos 35° - 150 \sin 30°$$
$$= 88.8 \, N$$

$$R_y = 200 \sin 35 + 150 \cos 30$$
$$= 244.62 \, N$$

$$R = 88.8 i + 244.62 j \, N$$

~~35~~

2/35 $\Sigma M_o = M_o$

$- 250 \cos 15 \times 200 + 250 \sin 15 \times 30 = M_o$

$M_o = -48296.29 + 1941.14$

$= -46355.14 \ N \cdot mm$

$= -46.355 \ N \cdot m$ because $-$ Sign So,

So, $46.355 \ \overset{N \cdot m}{\longleftrightarrow} (CW)$ It is in C.W direction.

2/36 $b^2 = a^2 + c^2$ $6mm = .6m$ $b/2$

$b = \sqrt{a^2 + c^2}$

$= \sqrt{(.6)^2 + \left(\frac{.6}{2}\right)^2} = .671m$

$\tan\theta = \dfrac{OA}{OB} \Rightarrow \theta = \tan^{-1}\left(\dfrac{.671}{.6}\right)$

$\theta = 48.2^\circ$

$\Sigma M_o = 0$
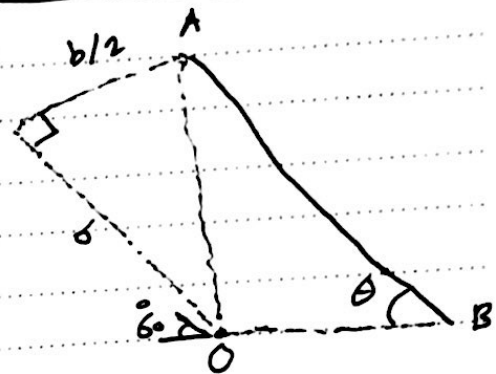
$M_o = OA_y \times T = OA_j \times T \cos\theta_i$

$= 0.671 \times 100 \cos 48.2$

$= -44.7 \ k \ N \cdot m$

$= 44.7 \ N \cdot m \ (CW)$

2/40 $M_B = P(1.6) \Rightarrow \boxed{M = F \cdot d}$

$= 30(1.6) = 48 \ N \cdot m \ (CCW)$

$M_A = P \cos 45 \ (1.6 \sin 45 + 1.6)$

$\quad\quad + P \sin 45 \ (1.6 \cos 45)$

$= 57.9 + 24 = 81.9 \ N \cdot m$

Then $M_A = 81.9 \ N \cdot m \ [CW]$

$P = 30N$

C $1.6m$ 45° B $1.6m$ A
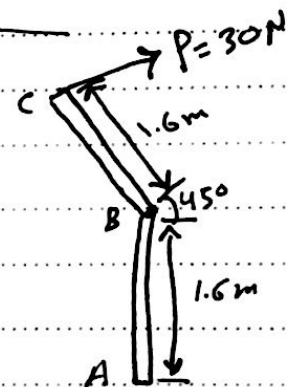
$235 \text{ mm} \rightarrow .235 \text{ m}$
$50 \text{ mm} \rightarrow 0.05 \text{ m}$

$F_x = F \cancel{\cos} \sin 10°$

$= 250 \sin 10° = 43.4 \text{ N}$

$F_y = F \cos 10°$

$= 250 \cos 10° = 246 \text{ N}$

$F = F_x i + F_y j \implies F = 43.4 i + 246 j \text{ N}$

$\Sigma M_o = M_o$

$M_o = F \cos 10° (.235) - F \sin 10° (0.05) = 0$

$M_o = 250 \cos 10° (.235 + F 250 \sin 10 (0.05))$

$= 57.85 + 2.17$

$= 60.03 \text{ N·m} \quad [CW]$

$\Sigma F_x = R$

$R = 120 - 200 = -80 \text{ N} = 80 \text{ N} (\leftarrow)$

$R = -80 N$

$\Sigma M_o = 0$

$R(d) = -200(160 \text{ mm}) + 120(240 \text{ mm})$

$-80 N (d) = -3200 \text{ N·mm}$

$d = \dfrac{-3200}{-80} \implies d = 40 \text{ mm}$

Location of R.

$\Sigma F_x = \cancel{R} 0$

$R = 90 + 90 + 90 = 270 \text{ kN}$

$\Sigma M_o = 0$

$R(d) = 90(21) + 90(12) + 90(21)$

$270(d) = \underset{1080}{\cancel{4860}} \text{ N·mm} \rightarrow d = \dfrac{\overset{1080}{\cancel{4860}}}{270} = 4 \text{ m}$

$4 \text{ m below } O$

① /

$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma M_0 = 0$$

‏* السؤال من kg أو N تضرب في 9.81

3/4 ① FBD

3.6 m

A ← 1.8 m → ↓ ← 1.2 m → B

$(50 \times 9.81)N, (300 \times 9.81) N$
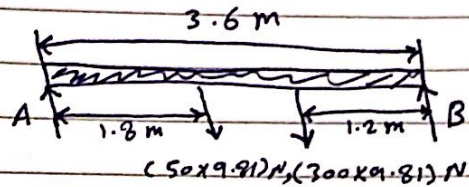
② $\Sigma M_A = 0$

$$By (3.6) - (50 \times 3.6 \times 9.81)(1.8) - (300 \times 9.81)(2.4) = 0$$
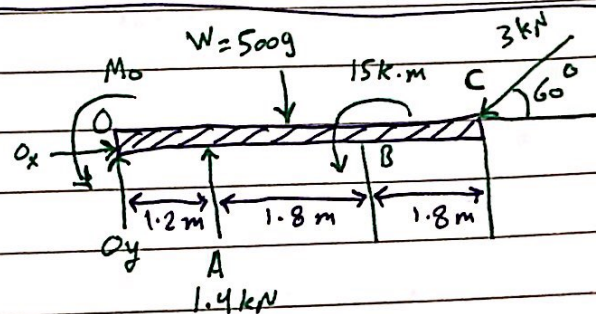
$$3.6 By - 10241.64 = 0 \qquad \boxed{By = 2844.9 \, N}$$

$\Sigma F_y = 0$

$$Ay + By - (50 \times 3.6 \times 9.81) - (300 \times 9.81) = 0$$

$$Ay + 2844.9 - (50 \times 3.6 \times 9.81) - (300 \times 9.81) = 0$$

$$\boxed{Ay = 1863.9 \, N}$$

3/5 ① FBD

$W = 500 g$ 15 k·m   3 kN   C   60°

M_0 O_x B

← 1.2 m → ← 1.8 m → ← 1.8 m →

O_y A

1.4 kN

② $\Sigma F_x = 0$

$$O_x - (3kN \cdot \sin 30) = 0$$

$$\boxed{O_x = 1500 \, N}$$

$$\Sigma F_y = 0 \, , \quad O_y + 1400 - 500g - 3000 \cos 30 = 0$$

$$O_y + 1400 - 500(9.81) - 3000 \cos 30 = 0$$

$$O_y + 1400 - 4905 - 2598.076 = 0$$

$$\boxed{O_y = 6103.076 \, N}$$

③

$$\Sigma M_0 = 0$$

$$M_0 + 1400 \times 1.2 + 15000 \, \phi - (500 \times 9.81)(2.4) - 3000 \cos 30° \times 4.8$$

$$\boxed{M_0 = 7562.766 \, N}$$

3.9 ① FBD

$\sum M_0 = 0$

① $-P(120) + (0.05 \times 9.81 \times 60) - F_s(40) = 0$
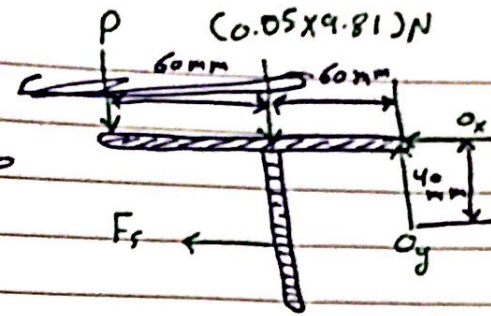
Calculate spring force

$F_s = kx$

$k = $ spring constant $= 1750 \, N/m$

$x = $ stratched length $= 0.01 \, m$

$F_s = (1750)(0.01) = 17.5 \, N$

$P(120) + (0.05 \times 9.81 \times 60) - 17.5(40) = 0$

$\boxed{P = 5.59 \, N}$
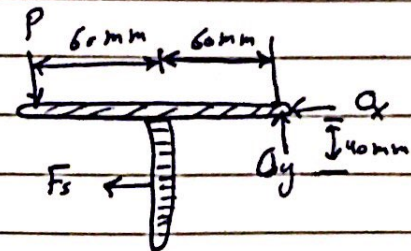
ⓑ ① FBD

$\sum M_0 = 0$

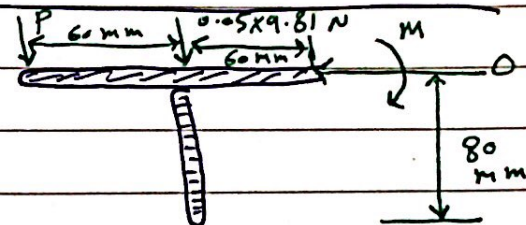$P(120) - F_s(40) = 0$

$120P - 17.5(40) = 0$

$\boxed{P = 5.83 \, N}$

3.10 ① FBD

$\sum M_0 = 0 \rightarrow M = 750 \, N \cdot mm$

$P(120) + (0.05 \times 9.81 \times 60) - 750 = 0$
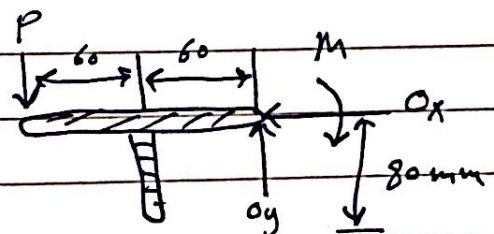
$120P - 720.57 = 0$

$\boxed{P = 6N}$

ⓑ FBD

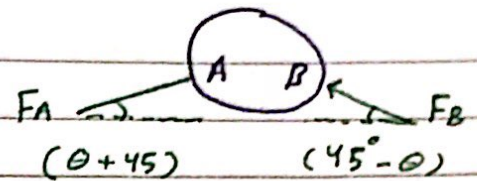$\sum M_0 = 0$

$P(120) - M = 0$

$120P - 750 = 0$

$\boxed{P = 6.25 \, N}$

3.15 ① FBD

$$\Sigma F_x = 0$$

$$F_A \cos(\theta - 45) - F_B \cos(45 - \theta) = 0$$

$$F_A \cos(\theta - 45) = F_B \cos(45 - \theta) \neq 0$$

F_A ⟶ A — B ⟵ F_B

$(\theta + 45)$ $(45° - \theta)$

~~assum~~ Then $\dfrac{F_A}{2} = F_B$

$$F_A \, \& \cos(\theta + 45) = \frac{F_A}{2} \cos(45 - \theta)$$

$$2\cos(\theta + 45) = \cos(45 - \theta)$$

$$2\cos u = \cos(90° - u)$$

$$2\cos u = \sin u$$

$$2 = \tan u$$

$$u = 63.43°$$

$u = \theta + 45°$

$$\theta = u - 45$$

$$\theta = 63.43 - 45° \implies \boxed{\theta = 18.43°}$$

3.16 ① FBD

$$\Sigma M_0 = 0$$

$$\Sigma M_0 = (22 \times T) - (88 \times 40)$$
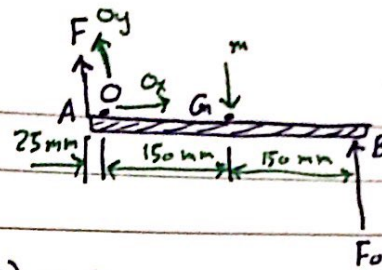
T ⟵   22mm   A

O   88 mm   40N

$$(22 \times T) \; \rule{0.6cm}{0.4pt} \; (88 \times 40) = 0$$

$$\boxed{T = 160N}$$

① FBD
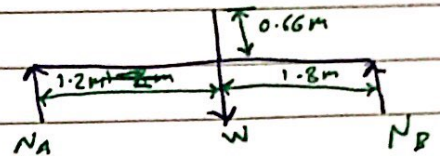
$\sum M_0 = 0$
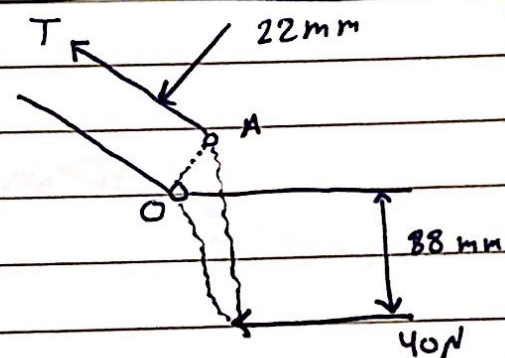
$-F(L_{OA}) - m(L_{OG}) + F_0(L_{OB}) = 0$

$-F(0.025)) - 1.5(0.15) + 16.31(0.3) = 0$

$$\boxed{F = 186.72 \text{ kg} = 1832 N}$$

3.46 ① FBD

(a)

$\sum M_B = 0$

$N_B \times 3m - W \times 1.2m = 0$

$N_B \times 3m - mg \times 1.2m = 0$
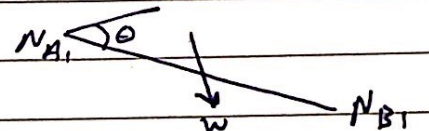
Then $m = 1600 \text{ kg}$
$g = 9.81 \text{ m/s}^2$

$$\boxed{N_B = \frac{1600 \times 9.81 \times 1.2}{3m} = 6278.4 N}$$

$N_A + N_B - mg = 0$

$N_A + 6278.4 - 1600 \times 9.81 = 0$

$$\boxed{N_A = 15696 N - 6278.4 = 9417.6 N}$$

Consider Car goes upward direction

$\tan\theta = $ slope   slope $= 10\%$

$\tan\theta = \frac{10}{100} \Rightarrow \theta = \tan^{-1}(0.1)$

$$\boxed{\theta = 5.71°}$$

Then $n_B = \left(\frac{N_{B1} - N_B}{N_B}\right) \times 100$

$N_{B1} \times 3m - 1.2m \times W \cos\theta - 0.66m \times W \sin\theta = 0$

$N_{B1} \times 3m - 1.2m \times mg \cos\theta - 0.66m \times mg \sin\theta = 0$

$N_{B1} \times 3m - 1.2m \times 1600 \times 9.81 \cos 5.71 - 0.66 \times 1600 \times 9.81 \sin 5.71 = 0$

$$\boxed{N_{B1} = 6591 N}$$

$$n_B = \left(\frac{N_{B1} - N_B}{N_B}\right) \times 100$$

$$= \frac{6591N - 6278.4N}{6278.4N} \times 100$$

$$= 4.98\%$$

$$n_A = \frac{N_{A1} - N_A}{N_A} \times 100$$

$$N_{B1} + N_{A1} - W \cos\theta = 0$$

$$N_{B1} + N_{A1} - mg \cos\theta = 0$$

$$6591N + N_{A1} - 1600(9.81) \cos 5.71 = 0$$

$$N_{A1} = 15618.12 - 6591$$
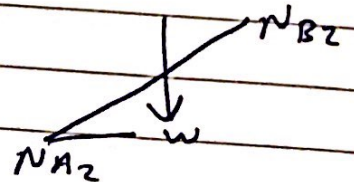
$$N_{A1} = 9027.12 N$$

$$n_A = \frac{9027.12N - 9417.6N}{9417.6N} \times 100 = -4.15\%$$

(b) $$N_{B2} \times 3 - 1.2m \times W \cos\theta + 0.66m \times W \sin\theta = 0$$

$$N_{B2} = 5904 N$$

$$n_B = \frac{N_{B2} - N_B}{N_B} \times 100$$

$$= \frac{5904 - 6278.4}{6278.4} \times 100 = -5.96\%$$

$$n_{A2} = \frac{N_{A2} - N_A}{N_A} \times 100$$

$$N_{B2} + N_{A2} - W \cos\theta = 0$$

$$N_{A2} = 15618.12 N - 5904 N$$

$$= 9714.12 N$$

$$n_A = \frac{9714.12 - 9417.6}{9414.6} \times 100 = 3.15\%$$

17)

$$\Sigma M_A = 0$$

$$W L_{AG} - N_B L_{AB} = 0$$

$$(1800 \times 9.81) \times 4 - N_B \times 4.8 = 0$$

$$N_B = 14720 \, N$$

$$\Sigma F_y = 0$$

$$N_A + N_B - W = 0$$

$$N_A + 14720 - 1800 \times 9.81 R = 0$$

$$N_A = 2940 \, N$$

$$\Sigma M_A = 0$$

$$W L_{AG} - N_B' + (T \cos 12)(0.550) = 0$$

$$(1800 \times 9.81) \times 4 - N_B' \times 4.8 + 3000 \sin 12 \times 0.550 = 0$$

$$N_B' = 15050 \, N$$

$$\Sigma F_y = 0$$

$$N_A' + N_B' - W + T \sin 12 = 0$$

$$N_A' + 15050 - (1800 \times 9.81) + 3000 \sin 12 = 0$$

$$N_A' = 1983 \, N$$

$$n_A = \frac{N_A' - N_A}{N_A} \times 100 = \frac{1983 - 2940}{2940} \times 100 = -32.6\%$$

$$n_B = \frac{N_B' - N_B}{N_B} \times 100 = \frac{15050 - 14720}{14720} \times 100 = 2.28\%$$